IEEE P627™/D2 Draft Standard for Qualification of Equipment Used in Nuclear Facilities

Prepared by the 2.10 Working Group of the

Qualification (SC-2) Committee

Abstract: This standard provides guidance on basic qualification principles and appropriate methods of demonstrating the qualification of equipment used in nuclear facilities. The principles, methods, and procedures described are intended to be used for qualifying equipment.

Keywords: equipment qualification, margin, qualification program, qualification documentation, safety, safety related, service condition, significant aging mechanisms

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Introduction

This introduction is not part of IEEE P627/D2, Draft Standard for Qualification of Equipment Used in Nuclear Facilities.

The requirements for qualification of safety system equipment are mandated by regulatory documents including the Code of Federal Regulations (CFR) and various industry standards. Among them are the following:

a) 10 CFR Part 50, Appendix A, General Design Criterion 2 (Design Bases for Protection Against Natural Phenomena) and General Design Criterion 4 (Environmental and Dynamic Effects Design Bases). This requires that structures, systems, and components important to safety be designed withstand the effects of natural phenomena such as earthquakes, … and to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant-accidents.

b) 10 CFR Part 50, Appendix B, Quality Assurance Criterion III (Design Control). This requires that design control measures be established and that such measures provide for verifying or checking the adequacy of design. One of the methods of design verification is by the performance of a suitable testing program.

c) 10 CFR Part 50.55a Codes and Standards, Protection System. This requires that the protection system meet the requirements set forth in Clause 4.4, Equipment Qualification, of ANSI/IEEE Std 279-1971™, Criteria for Protection Systems for Nuclear Power Generating Stations.

d) ANSI/ASME BPV-III, ASME Boiler and Pressure Vessel Code, Section III.

e) Clause 4.7, Equipment Qualification, of IEEE Std 308™, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

f) Clause 4.6, Equipment Qualification, of IEEE Std 603™, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

g) Clause 3.3, Equipment Qualification, of ANSI/ANS-56.7-1978 (W 1997), Boiling Water Reactor Containment Ventilation Systems.

h) Clause 3.3, Component Performance Requirements, of ANSI/ANS-56.6-1986 (W 1996), Pressurized Water Reactor Containment Ventilation Systems.

i) Clause 4.6, Isolation Barrier Environmental Provisions, of ANSI/ANS-56.2-1984 (W 1999), Containment Isolation Provisions for Fluid Systems.

Efforts on this standard were originally begun in late 1975 at the request of the IEEE Nuclear Standards Management Board. In 1977 a joint ASME/IEEE agreement established responsibility for qualification and quality assurance standards preparation. ASME accepted responsibility for Quality Assurance and IEEE for qualification. In accordance with that agreement, IEEE completed the generic qualification standard which is this standard in 1980. This document provided high level approaches, criteria, guidance, and principles for qualification of both electrical and mechanical equipment that at that time appeared in no other industry standard. IEEE Std 627**™**-1980 was later reaffirmed in 1996.

In 1986, ASME's Board on Nuclear Codes and Standards directed its Committee on Qualification of Mechanical Equipment (QME) to develop a standard for qualifying mechanical equipment. This task was completed in several parts during the time frame from 1992 to 1994. Partly in response to this activity, IEEE Std 627™ was withdrawn in 2002.

Later although withdrawn, it was found that IEEE Std 627™ was continuing to be used and referenced by many entities both in the US and other countries including in ASME's QME-1-2002 "Qualification of

Active Mechanical Equipment Used in Nuclear Power Plants", US NRC's NUREG-0800 Standard Review Plan Section 3.11, at least one reactor vendor's Design Certification Document (DCD), several international licensing documents, and elsewhere. As a result, in 2007, the IEEE Standards Board authorized Working Group 2.10 of Subcommittee 2 (Qualification) of the Power Engineering Society's Nuclear Power Engineering Committee to resurrect and update IEEE Std 627™-1980 (Reaff 1996).

This revision has incorporated the following improvements to reflect current practices and user needs:

- The resulting standard is an upper tier document to both IEEE Std 323™ and ASME QME-1.
- Allowance for Owner discretion to apply this standard to other than safety system equipment and to facilities other than nuclear power generating stations.
- The term design qualification has been replaced by equipment qualification or just qualification (because the term design qualification is not widely used).
- Deletions, additions to and updates in several of the definitions have been made (such as design qualification, equipment qualification, common mode and common cause failures, DBE Period of Operability, and margin).
- Minor changes in the names of Clauses 5 and 6 and rearranging of wording to match the clause titles have been made to facilitate future reference.
- An informative block diagram has been added to clarify the relationship between this standard and other qualification references.
- An informative annex clarifying various terms related to safety for possible use by facility Owners in determining when qualification should be invoked has been added.
- An informative bibliographical annex with a comprehensive list of qualification references has been added.

This standard was written and continues to serve as a general standard for qualification of all types of safety system equipment, mechanical and instrumentation as well as electrical. It also establishes principles and procedures to be followed in preparing specific safety system equipment standards. Guidance for qualifying specific types of safety system equipment may be found in various equipment-specific qualification standards (See Annex B).

It is required that safety system equipment in nuclear facilities meets or exceeds its performance requirements throughout its installed life. This is accomplished by a disciplined program of qualification and quality assurance of design, production, installation, maintenance and surveillance. This standard is for the qualification section of the program only. Normal production testing and preoperational testing (i.e., functional testing) performed after installation and acceptance of the equipment is outside the scope of this standard.

Qualification is intended to demonstrate the capability of the equipment design to perform its safety function(s) over the expected range of normal, abnormal, design basis event, post design basis event, and in-service test conditions. Inherent to qualification is the requirement for demonstration, within limitations afforded by established technical state-of-the-art, that in-service aging throughout the qualified life established for the equipment will not degrade safety system equipment from its original design condition to the point where it cannot perform its required safety function(s) upon demand. The above requirement reflects the primary role of qualification to provide reasonable assurance that design- and age-related common failure modes will not occur during performance of safety function(s) under postulated service conditions.

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Draft Standard for Qualification of Equipment Used in Nuclear Facilities

1. Overview

1.1 Scope

This standard provides the basic principles for qualification of equipment used in nuclear facilities.

1.2 Purpose

The purpose of this standard is to provide basic principles and guidance to demonstrate the qualification of equipment. Qualification is intended to confirm the adequacy of the equipment design to perform its safety function or safety functions over the expected range of normal, abnormal, design basis event, post design basis event, and in-service test conditions.

1.3 Annexes

This standard includes an informative (non-mandatory) annex that clarifies various terms related to safety and used by various organizations. Such terms include, but are not limited to safety, safety-related, Class 1E, Category 1, and important to safety. The intent is that clarification of such terms will allow a facility Owner to be able to make a more informed decision regarding which equipment needs to be qualified. It also includes an informative (non-mandatory) annex that describes references relevant to the creation of this standard and lists other standards related to equipment qualification.

2. Normative References

This standard shall be used in conjunction with the following standards. The latest edition of the referenced document (including any amendments or corrigenda) applies. [1,2]

[1] The IEEE standards or products referred to in Clause 2 are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.

ASME QME-1 [B4][3], Qualification of Active Mechanical Equipment Used in Nuclear Power Plants.

IEEE Std 323™ [B12], IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

IEEE Std 334™ [B13], IEEE Standard for Type Tests of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations.

IEEE Std 344™ [B15], IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.

IEEE Std 382™ [B16], IEEE Standard for Qualification of Safety-Related Valve Actuators.

IEEE Std 383™ [B17], Type Test of Class 1E Electric Cables, IEEE Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations

IEEE Std 603™ [B23], IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

IEEE Std 1205™ [B30], IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations.

3. Definitions

The following terms and definitions are considered important for accurate interpretation of this standard. These definitions establish the meanings of words in the context of their use in the standard. *The Authoritative Dictionary of IEEE Standards*, Seventh Edition [B6] should be referenced for terms not defined in this clause.

3.1 aging: The cumulative effects of operational, environmental and system conditions on equipment during a period of time up to, but not including design basis events, or the process of simulating these events.

3.2 analysis: A course of reasoning showing that a certain result is a consequence of assumed premises.

3.3 auditable data: Information which is documented and organized in a readily understandable and traceable manner that permits independent assessment of inferences or conclusions based on the information.

NOTE—Examples of information include product catalog information, dimensional drawings, bills of material, engineering specifications, performance specifications, installation and calibration instructions and manuals, maintenance manuals, test reports and analyses.

3.4 code classes: Levels of structural integrity and quality commensurate with the relative importance of the individual mechanical components of the nuclear facility.

NOTE—For the recognized code classes, refer to the following documents:

ANSI/ANS 51.1-1988 [B1], Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants.

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[2] IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).
[3] The numbers in brackets correspond to those of the bibliography in Annex A.

ANSI/ANS 52.1-1988 [B2], Nuclear Safety Criteria for Design of Stationary Boiling Water Reactor Plants.

ANSI/ASME BPV-III [B3], Boiler and Pressure Vessel Code and its latest addenda, Section III.

3.5 common-cause failure: Loss of function to multiple systems, structures or components due to a shared initiating event.

3.6 common-mode failure: Loss of function in multiple systems, structures or components through the same mechanism or in the same manner.

3.7 components: Items from which equipment is assembled (for example, attachments, bearings, bolts, capacitors, connectors, governors, inspection access ports, instrument sensors, locking devices, position indicators, resistors, seals, sight glasses, springs, switches, transistors, tubes, wires, etc).

NOTE—Certain items, for example, instrument sensors, may satisfy the definition of the term component or the term equipment as used in this standard. Where such items are included within defined boundaries of equipment items, they are correctly referred to as components. Where such items are installed outside of defined boundaries for equipment items and perform independent functions, they are correctly referred to as equipment.

3.8 containment: That portion of the engineered safety features designed to act as the principal barrier, after the reactor system pressure boundary, to prevent the release, even under conditions of a reactor accident, of unacceptable quantities of radioactive material beyond a controlled zone.

3.9 DBE Period of Operability: the period of time during a DBE that the equipment must perform its required function and not fail in a manner detrimental to plant safety or accident mitigation.

3.10 demonstration: The provision of evidence to support the conclusion derived from assumed premises.

3.11 design basis events (DBE): Postulated events used in the design to establish the acceptable performance requirements for the structures, systems, and components.

3.12 design life: The time period during which satisfactory performance can be expected for a specific set of service conditions.

NOTE—The time period may be specified in real time, operating time, number of operating cycles or other performance interval, as appropriate.

3.13 engineered safety features: Features of a unit other than reactor trip or those used only for normal operation, that are provided to prevent, limit, or mitigate the release of radioactive material.

3.14 equipment: As assembly of components designed and manufactured to perform specific functions.

NOTE—Certain items which satisfy the definition of the term equipment as used in this document are those referred to as components in the ASME Boiler and Pressure Vessel Code and its latest addenda [B3], Section III (ANSI/ASME BPV-III), for example, pumps and valves. Other examples of equipment are motors, transformers, and instrumentation and control devices. Structures and structural support items are not included in the definition of equipment.

3.15 equipment qualification: The generation and maintenance of evidence to ensure that equipment will operate on demand to meet system performance requirements during normal and abnormal service conditions and postulated design basis events.

NOTE—Equipment qualification includes environment and seismic qualification.

3.16 failure: The loss of ability of a component, equipment or system to perform a required function within required performance criteria.

3.17 installed life: The interval from installation to removal, during which the equipment or component thereof may be subject to design service conditions and system demands.

NOTE—Equipment may have an installed life of 40 years with certain components changed periodically; thus, the installed life of the changed components would be less than 40 years.

3.18 margin: The difference between service conditions and the conditions used for equipment qualification.

NOTE—An alternative, acceptable definition for margin from ASME QME-1-2002 [B4] is the amount by which the qualification condition levels exceed the service condition levels.

3.19 operating experience: Verifiable service data for equipment.

3.20 qualified life: The period of time, prior to the start of a design basis event, for which the equipment was demonstrated to meet the design requirements for the specified service conditions.

NOTE—At the end of the qualified life, the equipment shall be capable of performing the function(s) required for the postulated design basis and post design basis events.

3.21 random failure: Any failure whose cause or mechanism, or both, makes its time of occurrence unpredictable.

3.22 sample equipment: Equipment, representative of a design, used to obtain data that are valid over a range of ratings and for specific service conditions.

3.23 service conditions: Environmental, loading, power and signal conditions expected as a result of normal operating requirements, expected extremes (abnormal) in operating requirements, and postulated conditions appropriate for the design basis events of the station.

4. Qualification Principles

4.1 Qualification Objective

The primary purpose of equipment qualification is to provide reasonable assurance that design and age-related common failure modes will not occur to multiple trains of safety system equipment impairing the equipment's ability to perform its safety function before, during, and after applicable design basis events.

The overall equipment qualification program is guided by the quality assurance / quality control program requirements considered in the design, fabrication and qualification of safety system equipment. Quality assurance/quality control program requirements are embodied in the equipment specification to control the design, procurement, fabrication, verification, and qualification process. Adherence to the quality program requirements provides assurance that the equipment is in compliance with established technical standards and criteria and is capable of performing its intended safety functions under applicable service conditions. The quality program requirements also delineate procedures for reporting design deficiencies and nuclear regulatory agency notification in the case of non-compliance. Adherence to the quality program requirements also provides assurance that production equipment is the same as, and is traceable to, the qualified design configuration.

As a result, the purpose of qualification is not to prevent all failures and, in particular, not to prevent failures caused by quality issues (such as manufacturing defects, equipment misoperation, and improper maintenance). Many such cases with no apparent cause are characterized as random failures.

The fundamental principles pertinent to the general concept of equipment qualification are provided in the following clauses. Detailed qualification requirements are found in other qualification standards which shall be applied, where appropriate.

4.2 Mandatory Requirements for Qualification

A qualification program for equipment used in a nuclear facility shall include the following:

a) Qualification criteria

b) A qualification program to demonstrate satisfaction of qualification criteria by analysis, test, operating experience or a combination of these.

c) Evidence of successful completion of qualification

d) Documentation containing (a), (b) and (c). The following clauses of this standard provide guidance to implement these requirements. Specific equipment qualification standards should define the requirements to satisfy (a), (b), (c), and (d).

The equipment qualification program shall be controlled by an approved Quality Assurance Program.

4.3 Fundamental Qualification Requirement

To establish equipment qualification, it shall be demonstrated that the equipment can perform the required function(s), when operational and environmental conditions are imposed on the equipment by occurrence of any postulated service condition, in accordance with the specifications.

4.4 Approaches to Qualification

Equipment shall be qualified to verify that its specification criteria are satisfied. The criteria generally cover a single application, but they may envelop the service conditions for more than one application. In addition, a family of equipment may be qualified by qualifying one or more members and extending the qualification across the family by analytical methods for compliance with guidelines given in specific equipment documents. Such analysis requires consideration of significant design parameters to establish the similarity of the qualified member(s) to the family of equipment.

The pressure containment integrity and passive structural requirements of mechanical equipment covered by ASME, AISC, ACI, or other applicable codes are considered qualified by adherence to those codes. Additional qualification requirements may apply to age-sensitive components, which are not addressed by these codes.

4.5 Other Qualification Considerations

4.5.1 Aging

The assessment of equipment aging effects is an essential part of the qualification process to determine if aging has a significant effect on safety function performance. The assessment shall include an analysis of the equipment to determine any significant aging mechanisms. When these mechanisms are identified, a suitable aging program shall be developed. This program, in conjunction with other parts of the qualification program, provides assurance that significant aging mechanisms are unlikely to contribute to common-cause failures adverse to the required function of the equipment. When natural aging is utilized in the qualification program, it may not be necessary to conduct a detailed analysis to determine significant aging mechanisms.

Aging is significant for the purpose of an aging program if it satisfies all of the following criteria:

a) In the normal service environments, an aging mechanism promotes the same failure mode as that resulting from exposure to abnormal or design basis event service conditions.

b) The aging mechanism adversely affects the ability of the equipment to perform its required function in accordance with its specification requirements.

c) The deterioration caused by the aging mechanism is not amenable to assessment by in-service inspection or surveillance activities that provide confidence in the equipment's ability to function in accordance with its specification requirements during the intervals between surveillance.

d) In the normal service environment, the aging mechanism causes degradation during the design life of the equipment that is appreciable compared to degradation caused by the design basis events.

4.5.2 Qualified Life

For equipment with significant aging mechanisms, a qualified life shall be established. For equipment with no significant aging mechanisms, its qualified life is effectively equivalent to design life.

The determination of qualified life depends upon the method employed for assessing aging effects in the aging program. Where naturally aged equipment is available for use in qualification, the qualified life determination and justification is straightforward. When natural aging is not used, the assessment of aging is less quantitative. The determination of qualified life shall be based upon conservative engineering analysis in these instances. The analysis may take into account, as available:

a) Results of age conditioning used in qualification

b) Equipment operating data

c) Previous test results

d) Understanding of significant aging mechanisms that have been identified.

NOTE—The qualified life of a particular equipment item may be changed during its installed life where justified.

The qualified life of equipment may be limited by certain components which have a qualified life less than the installed life of the equipment. By periodic maintenance or by periodically changing those components, the qualified life of the equipment may be extended.

4.5.3 Margin

Margin shall be considered in the qualification program to account for reasonable uncertainties in demonstrating satisfactory performance, normal variations in commercial production, and uncertainties in measurement and test equipment, thereby providing greater assurance that the equipment can perform under the most adverse service conditions for which it is qualified.

Inclusion of margin makes the equipment qualification more severe than the equipment application. Margin includes, but is not limited to, more severe service conditions, additional aging, additional cycles, additional transient events, and more restrictive performance criteria.

Because of the variety of equipment that must be qualified and the different demands made on equipment, it may not be practical to specify generally applicable margins. In identifying margin, it is permissible to take into consideration quantifiable conservatisms already applied. Existence of such conservatisms in the service conditions should be specified. Specific equipment qualification standards should provide detailed guidelines on margins. For example, IEEE Std 323™ [B12], IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations, provides guidance for margin in design basis event service conditions.

5. Elements of a Successful Facility Equipment Qualification Program

5.1 General Program Requirements

A qualification program shall be developed to demonstrate the capability of equipment to meet specified qualification requirements and acceptance criteria. If a standard exists for the specific type of equipment, it should be the basis for qualification; otherwise, the principles of this clause shall be applicable.

The facility qualification program shall require specifications for safety system equipment to describe all the criteria to be met to qualify the equipment for its intended application. These criteria form the basis for development of an equipment qualification program. These elements shall be completely defined and implemented to successfully demonstrate qualification of the equipment. As a minimum, the following shall be included:

a) Equipment performance requirements including a description of its safety function(s)

b) The equipment boundary, including components that are inside the boundary, and the physical orientation of the equipment

c) Description of interfaces, loads, power sources and control signals, as applicable

d) Design codes and standards applicable to the design of the equipment

e) Specific qualification standards, if any, that pertain to the specific type of equipment

f) Definition of the service conditions for the equipment inclusive of any required margin

g) Identification of significant aging mechanisms, if applicable

h) Acceptance criteria for qualification

i) Requirement for documentation of the equipment qualification.

The final step in the formulation of the equipment qualification program is the development of the qualification plan / procedure using the elements of the qualification program previously discussed.

5.2 Performance Requirements

The equipment qualification specification shall describe the type of nuclear facility and system in which the equipment is to be installed, if relevant to qualification. The specification shall describe the specific safety function(s) and associated performance criteria of the equipment. Components and subassemblies that are not involved in the equipment's safety function(s) may be excluded from the qualification process if it can be shown that their failures have no adverse effect on the stated safety function(s) or, via interfaces, the safety function(s) of other equipment.

5.3 Equipment Description and Boundary

The equipment to be qualified shall be specified in detail. The boundary of the equipment, including components inside the boundary, shall be defined. Attachments, motive power connections, seals, and control circuitry that cross this boundary shall be described as discussed in 5.5. Since the orientation and mounting of the equipment may be significant for the qualification procedure, such as the position of a valve actuator assembly in other than a vertical configuration, it shall be described.

The component identification should include identification of materials of construction, with an indication of which materials are age sensitive. Additionally, the component description should indicate whether the component is essential to equipment operation.

If the qualification program is designed to develop qualification of multiple equipment models in the same family, justification shall be provided to demonstrate the selection of an equipment model for qualification and its similarity and applicability to other models proposed to be qualified.

5.4 Interfaces

Interface loadings via physical attachments of the equipment at the equipment boundary shall be specified for each operating mode. These external loads shall be simulated or analyzed during the qualification program to provide assurance that the equipment can perform its required function(s). In the same manner, motive power or control signal inputs, including those that deviate from normal, must be specified.

Equipment being qualified may include a combination of component parts that are designed and standardized according to different technical disciplines. For example, the overall qualification of a vertical motor-driven pump for a safety system application may include as many as four technical disciplines:

a) Mechanical: pump design

b) Electrical: motor design and power source qualification

c) Structural: foundation design

d) Instrumentation: control and sensor qualification.

In consideration of the equipment boundary for qualification purposes, the interface between the pump and its motor drive is inside the equipment boundary, while other interfaces between the pump and its foundation, or the motor drive power source and control signals, are at the equipment boundary. For this example, the design of these interfaces is important to the successful qualification of the pump assembly when, as a system, it is subjected to seismic or vibration induced forces that originate outside the equipment boundary. In the same manner, variation in motive power characteristics or control signals from normal values can affect the functional performance capability of the pump assembly. Interface connections shall be qualified to accommodate these system effects.

5.5 Design Codes and Standards

Equipment specifications for Safety System, Class 1E or Code Class equipment, shall reference by specific numbers, those applicable sections of the design codes and standards. Pertinent supplementary standards such as ACI, ANSI, ASTM, IEEE, ISA, or other technical standards applicable to equipment or components shall also be referenced.

5.6 Specific Equipment Qualification Standards

Specific equipment qualification standards that are applicable to the equipment shall be referenced and applied in whole or in part as pertinent to the equipment. Figure 1 provides a graphical hierarchy of the relationship between this standard and other equipment qualification standards.

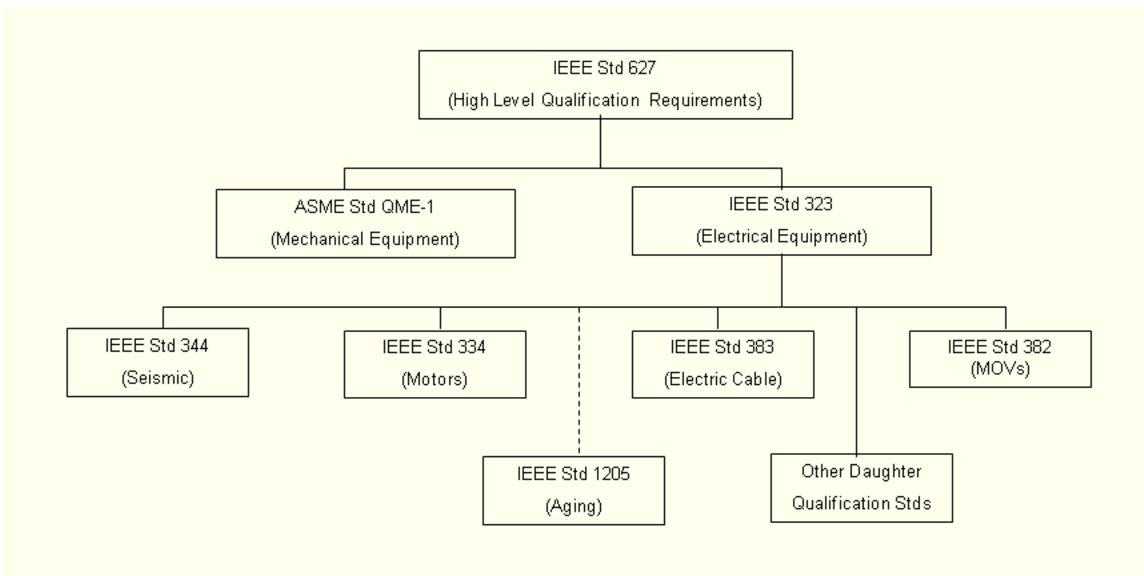

Figure 1 IEEE Std 627™ Relationship to Other Standards

5.7 Service Conditions and Margin

A range of values for local environmental and equipment operational parameters shall be specified reflecting expected service conditions for the particular application. Examples of such parameters are:

a) External pressure

b) Ambient temperature

c) Relative humidity

d) Radiation: hourly rate or integrated dose, or both. Specify gamma, beta, and neutron, as applicable

e) Vibration

f) Duty Cycle: normal operation

g) Load delivered

h) Chemical spray or other conditions that can cause corrosion

i) Power supply

j) EMI/RFI

Specification of service conditions and conditions resulting from design basis events (for example, seismic, loss of coolant accident, high energy line-break accident, reactivity insertion, loss of reactor coolant pumps, etc) for the equipment and the nature of functions to be performed is required. The time period the equipment must remain operable shall also be specified. The service conditions postulated for these events shall be expressed as an estimated time history for each parameter that may affect equipment function(s) during the event. As discussed in 4.4.3, any margin included in the specified value of qualification parameters shall be indicated.

5.8 Significant Aging Mechanisms

Significant aging mechanisms, where known, shall be identified to determine an appropriate method to address equipment aging and identification of the equipment qualified life objective, if any.

NOTE—An equipment's continued qualification should be periodically reviewed over its installed life in conjunction with the plant preventative maintenance and surveillance program to address unexpected performance degradation as well as excessive conservatisms. Monitoring and preventative maintenance should be considered to assure qualification is maintained.

5.9 Acceptance Criteria

Comprehensive criteria shall be specified to assure satisfaction of the fundamental qualification requirement. The acceptance criteria shall include limiting values of input to and performance required from the equipment under the required operating conditions, as well as environmental parameter levels.

5.10 Documentation

The qualification of the equipment shall be documented by a qualification file. The type of data to be included in the file is specified in Clause 7.

6. Selection of Qualification Methods

6.1 Selection Factors

Qualification of safety system equipment shall be accomplished by test, analysis, documented operating experience, or some combination of these methods. A qualification program usually involves a combination of the three basic methods. The applicability of a qualification method is based on many factors. These factors include, but are not limited to, equipment type, physical size and complexity, equipment function, operability requirements, cost, and previous qualification data of similar equipment.

6.2 Qualification by Test

Type testing is the preferred method for qualification of safety system equipment. The type test shall be designed to demonstrate that the equipment performance meets or exceeds the required function(s) for the plant conditions throughout its design or qualified life. The type test shall consist of a planned sequence of test conditions, including qualification margin.

6.3 Qualification by Analysis

Qualification by analysis shall demonstrate that the performance of the equipment to be qualified meets or exceeds its specified functional requirements when subjected to normal, abnormal, seismic, and Design Basis Accident (DBA) service conditions. In general, the analysis shall be based on established principles, operating experience data, partial type test data, or combinations of these. All assumptions, including extrapolations, shall be justified by stating principles and/or verifiable test data.

6.4 Qualification by Operating Experience

Qualification for certain types of equipment may employ operating experience-based environmental qualification through the use of maintenance and surveillance.

6.5 Qualification by Combined Methods

Qualification by combined methods such as testing and analysis is used whenever qualification by type test is not the sole basis of qualification. If analysis is used, justification shall be provided for the use of the analysis. Justification shall also be provided addressing concerns related to departure from the required type test sequence.

7. Documentation

7.1 General Documentation Requirements

The qualification documentation shall verify that the equipment meets its functional and performance requirements. The basis for claiming qualification shall be explained in a clear logical fashion. Evidence shall be presented to show that (1) the fundamental qualification requirement is satisfied and (2) the qualified life is justified. Data used to demonstrate the qualification of the equipment shall be pertinent to the application and organized in an auditable form. In addition, any aging processes not treated during equipment qualification, but reserved for in-service surveillance monitoring, shall be specifically identified.

7.2 Documentation Files

The end user shall maintain a qualification file(s) consistent with the plant's current licensing basis, not necessarily at the nuclear facility site. The file(s) shall contain the equipment specification criteria and shall include:

a) Documentation that demonstrate equipment qualification

b) Evidence of compliance with specified design codes and standards

c) Evidence of compliance with functional qualification standards

d) Description of periodic inspection, maintenance and component replacement requirements during the lifetime duty cycle

e) Summary and conclusions

f) Approval signature and date.

Annex A

(informative)

Safety Terminology

A.1 Background and Objective

During the years that nuclear power generating stations and other nuclear facilities have been licensed and built, various terminology such as safety and safety-related have been used to characterize structures, systems, items of equipment, and components that have an essential active or passive function to protect the health and safety of the public. The purpose of this annex is to summarize these various terms with the intent of assisting facility Owners in defining the scope of items to be qualified.

NOTE—This annex contains many definitions extrapolated from other documents. These other documents should always be consulted for the most up-to-date definition, although minor changes should not affect the guidance provided below.

A.2 Safety and Safety-Related

One consideration to the decision on need for equipment qualification is whether the item performs a safety function as part of a safety system.

The two lead IEEE nuclear design standards IEEE Std 308™ [B10] "IEEE *Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations*" and IEEE Std 603™ [B23] "*IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations"* define a safety system in terms of performance of a safety function or more specifically:

A safety system is any system (reactor trip system, an engineered safety feature, or both including auxiliary supporting features) which provides a safety function

where:

an auxiliary supporting feature is a system or component which provides services (such as cooling, lubrication, and energy supply) which are required for the safety system to accomplish its safety functions

and

a safety function is one of the processes or conditions (for example, emergency negative reactivity insertion, post accident heat removal, emergency core cooling, post accident radioactivity removal, and containment isolation) essential to maintain parameters within acceptable limits established for a design basis event.

By extrapolation, a safety structure, system, item of equipment, or component is one which provides a safety function.

In general, IEEE, ASME, and other industry standard sponsoring organizations use the terms safety systems, safety equipment, and safety components; whereas regulatory authority documents, in general, use the term safety-related. For example:

Safety-related structures, systems and components are those structures, systems and components that are relied upon to remain functional during and following design basis events to assure: (1) The integrity of the reactor coolant pressure boundary, (2) The capability to shut down the reactor and maintain it in a safe shutdown condition; or (3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guideline exposures set forth in § 50.34(a)(1) or § 100.11 of this chapter, as applicable. [US NRC 10 CFR 50.2]

Note that this definition of safety-related is also based on performance of a safety function. For purposes of this annex, the terms safety and safety-related are considered synonymous.

A.3 Class 1E, Class 1, and Seismic Category I

Safety and safety-related are defined in terms of providing a safety or safety-related function. Similarly, Class 1E, Class 1, and Seismic Category I are examples of classes of design imposed on a structure, system, item of equipment, or component to assure it performs its function for a required design basis event. This class of design consists of one or more design requirements, such as single failure criterion, quality assurance, environmental qualification, seismic qualification, independence, testability, and others. For example:

Class 1E is a safety classification of [design for] electric equipment and systems essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or is otherwise essential in preventing significant release of radioactive material to the environment. [IEEE Std 308™ [B10] and IEEE Std 603™ [B23]]

The ASME Boiler and Pressure Vessel Code provides design requirements for Safety Class 1, (as well as Safety Class 2, and Safety Class 3).

Seismic Category I is a class of design applied to those structures, systems, and components designed to withstand the effects of a safe shutdown earthquake and remain functional. [US NRC Regulatory Guide 1.29 [B48]]

A.4 The Design Concept of Not-Fail-Detrimental-to-a-Safety-Function

Another consideration for equipment qualification is the need to design structures, systems, equipment items, and components in a way where failure cannot be detrimental to a safety function. Specifically, for electrical equipment:

where a single credible event, including all direct and consequential results of that event, can cause a non-safety system action that results in a condition requiring protective action, and can concurrently prevent the protective action in those sense and command feature channels designated to provide principal protection against the condition, then one of three design requirements shall be met, one of which is equipment qualification. [IEEE Std 603™, Section 6.3.1 [B23]]

Similarly, the class of Seismic Category II/I imposes design consideration to assure that non-safety structures, systems, equipment items, and components will not fail and fall during an SSE in way that detrimentally affects performance of any safety functions.

A.5 Accident Monitoring Instruments

A third consideration for equipment qualification is whether an instrument is required to operate during a design basis event for accident monitoring purposes. IEEE Std 497™ [B20] provides guidance on which types of accident monitoring instruments require equipment qualification.

A.6 Other Related Terms and Definitions

The following additional terms may be used to provide insight into whether equipment qualification should be considered:

Important to Safety is a broader group of structures, systems, equipment, and components than those which are just safety-related. For example, this term would additionally include non-safety-related equipment (whose failure could prevent safety-related functions) and certain post accident monitoring equipment. [10 CFR 50.49]. But this term may possibly also include portions of or all fire protection, security, and radiological waste systems. For this reason, this term, although having some usefulness, has not received universal acceptance among both plant owners and regulatory authorities.

Safety significant relates to the role a safety or non-safety structure, system, or component plays in preventing the occurrence of an undesired end state such as core melt or large early release. This determination is made based on probabilistic risk assessment analytical techniques. [Based on Regulatory Guide 1.174 [B51], Rev 1 "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis"]

Items Relied on For Safety: Structures, systems, equipment, components, and activities of personnel that are relied on at a Special Nuclear Material Facility to prevent potential accidents that could exceed performance requirements of 10 CFR 70.61 or to mitigate their potential consequences. [10 CFR 70.4]

Annex B

(informative)

Bibliography

Other standards and documents related to equipment qualification are as follows:

[B1] ANSI/ANS 51.1-1988, Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants. (withdrawn)

[B2] ANSI/ANS 52.1-1988, Nuclear Safety Criteria for Design of Stationary Boiling Water Reactor Plants. (withdrawn)

[B3] ANSI/ASME BPV-III, Boiler and Pressure Vessel Code and its latest addenda, Section III.

[B4] ASME-QME-1-2002, Qualification of Active Mechanical Equipment Used in Nuclear Power Plants.

[B5] IEC 60780 1998-10, Nuclear Power Plants – Electrical Equipment of the Safety System – Qualification.

[B6] IEEE 100, The Authorative Dictionary of IEEE Standards Terms, Seventh Edition.

[B7] IEEE Std 99™-2007, IEEE Recommended Practice for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment.

[B8] IEEE Std 101™-1987 (Reaff 2004), IEEE Guide for the Statistical Analysis of Thermal Life Test Data.

[B9] IEEE Std 279™-1971, IEEE Standard: Criteria for Protection Systems for Nuclear Power Generating Stations.

[B10] IEEE Std 308™-2001 (Reaff 2007), IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

[B11] IEEE Std 317™-1983 (Reaff 2003), IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.

[B12] IEEE Std 323™-2003, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

[B13] IEEE Std 334™-2006, IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations.

[B14] IEEE Std 338™-2006, IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems.

[B15] IEEE Std 344™-2004, IEEE Recommended Practice for Seismic Qualification of Class 1E equipment for Nuclear Power Generating Stations.

[B16] IEEE Std 382™-2006, IEEE Standard for Qualification of Actuators for Power-Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants.

[B17] IEEE Std 383™-2003, IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

[B18] IEEE Std 387™-1995 (Reaff 2001), IEEE Standard Criteria for Diesel-Generator Units Applied as Power Standby Supplies for Nuclear Power Generating Stations.

[B19] IEEE Std 420™-2001, IEEE Standard for the Design and Qualification of Class 1E Control Boards, Panels, and Racks Used in Nuclear Power Generating Stations.

[B20] IEEE Std 497™-2002, IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations.

[B21] IEEE Std 535™-2006, IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations.

[B22] IEEE Std 572™-2006, IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations.

[B23] IEEE Std 603™-1998, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations

[B24] IEEE Std 628™-2001 (Reaff 2006), IEEE Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations.

[B25] IEEE Std 638™-1992 (Reaff 2006), IEEE Standard for Qualification of Class 1E Transformers for Nuclear Power Generating Stations.

[B26] IEEE Std 649™-2006, IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations.

[B27] IEEE Std 650™-2006, IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations.

[B28] IEEE Std 943™-1986 (Reaff 1992), IEEE Guide for Aging Mechanisms and Diagnostic Procedures in Evaluating Electrical Insulation Systems.

[B29] IEEE Std 1064™-1991, IEEE Guide for Multifactor Stress Functional Testing of Electrical Insulation Systems.

[B30] IEEE Std 1205™-2000 (Reaff 2007), IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations.

[B31] IEEE Std C37.81™-1989 (Reaff 2005), IEEE Guide for Seismic Qualification of Class 1E Metal-Enclosed Power Switchgear Assemblies.

[B32] IEEE Std C37.82™-1987 (Reaff 2004), IEEE Standard for the Qualification of Switchgear Assemblies for Class 1E Applications in Nuclear Power Generating Stations.

[B33] IEEE Std C37.98™-1987 (Reaff 1999), IEEE Standard Seismic Testing of Relays.

[B34] IEEE Std C37.105™-1987 (Reaff 1999), IEEE Standard for Qualifying Class 1E Protective Relays and Auxiliaries for Nuclear Power Generating Stations.

[B35] IEEE Std C62.41.1™-2002, IEEE Guide on the Surge Environment in Low-Voltage (100 V and less) AC Power Circuits.

[B36] IEEE Std C62.41.2TM-2002, IEEE Recommended Practice on Characterization of Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.

[B37] IEEE Std C62.45™-2002, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.

[B38] NRC IE Bulletin 79-01B, Environmental Qualification of Class 1E Equipment, February 1979.

[B39] NRC IN 94-20, Common-Cause Failures Due to Inadequate Design Control and Dedication, March 1994.

[B40] NUREG-0588, Rev. 1, Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment, July 1981.

[B41] Section 3.11, Environmental Qualification of Mechanical and Electrical Equipment, of NUREG 0800, Standard Review Plant for the Review of safety Analysis Reports for Nuclear Power Plants.

[B42] NUREG/CR-5700, Aging Assessment of Reactor Instrumentation and Protection System Components, July 1992.

[B43] NUREG/CR-5904, Functional Issues and Environmental Qualification of Digital Protection Systems of Advanced Light-Water Nuclear Reactors, April 1994.

[B44] NUREG/CR-6384, BNL-NUREG-52480, Volume 1, Literature Review of Environmental Qualification of Safety-Related Electric Cables, April 1996.

[B45] NUREG/CR-6384, BNL-NUREG-52480, Volume 2, Literature Review of Environmental Qualification of Safety-Related Electric Cables: Literature Analyses and Appendices, April 1996.

[B46] NUREG/CR-6406, Environmental Testing of an Experimental Digital Safety Channel, September 1996.

[B47] NUREG/CR-6579, Digital I&C Systems in Nuclear Power Plants: Risk-Screening of Environmental Stressors and a Comparison of Hardware Unavailability with an Existing Analog System, January 1998.

[B48] Regulatory Guide 1.29, Rev. 4, Seismic Design Classification, March 2007.

[B49] Regulatory Guide 1.89, Rev. 1, Environmental Qualification of Certain Electrical Equipment Important to Safety for Nuclear Power Plants, June 1984.

[B50] Regulatory Guide 1.97, Rev. 4, Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants, June 2006.

[B51] Regulatory Guide 1.174, Rev 1, An Approach For Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis, November 2002.

[B52] Regulatory Guide 1.180, Rev. 1, Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems, October 2003.

[B53] Regulatory Guide 1.209, Guidelines for Environmental Qualification of Safety-Related Computer Based Instrumentation and Control Systems in Nuclear Power Plants, March 2007.